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Bisa Neuro–Techno–Ethno Policy Framework: Reimagining Education Policy Analysis for a Sustainable and Contextually Responsive Learning Ecosystem

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Abstract
This study develops an integrative framework for education policy analysis, namely the Neuro–Techno–Ethno Policy Framework (NTEPF), by synthesizing insights from neuroscience, digital transformation, and ethnopedagogy. Contemporary policy approaches tend to operate in fragmented paradigms, limiting their capacity to address complex and context-dependent educational challenges. This research employs a conceptual qualitative design using critical literature synthesis and theory-building methodology. The findings indicate that effective policy depends on the alignment between cognitive processes, technological infrastructures, and cultural contexts. The proposed framework contributes to education policy theory by bridging micro-level learning dynamics with macro-level governance structures. It also provides a practical direction for designing adaptive, inclusive, and sustainable learning ecosystems.

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1. INTRODUCTION

Education policy today exists in an increasingly complex landscape, influenced by digital transformation, global inequality, and ever-changing sociocultural dynamics. The rational-comprehensive policy model, which has served as its primary foundation, is beginning to be questioned due to its linear tendencies and lack of responsiveness to the uncertainty and complexity of modern education systems (Cairney, 2021; Peters, 2022; Weible & Sabatier, 2018).

The development of evidence-informed policy approaches has indeed made important contributions to more systematic decision-making. However, these approaches often place quantitative data at the center of analysis, neglecting the contextual and interpretive dimensions that are crucial to the success of policy implementation (Biesta, 2020; Head, 2022; Parkhurst, 2020). In contrast, interpretive and critical approaches emphasize meaning, discourse, and power relations but have not yet fully provided an applicable operational framework (Yanow, 2021).

On the other hand, findings in educational neuroscience indicate that the learning process is strongly influenced by emotional engagement, cognitive load, and social interactions (Immordino-Yang, 2022; Howard-Jones, 2021). Unfortunately, these dimensions are rarely integrated into educational policy design, creating a gap between understanding how humans learn and how policies are designed.

Digital transformation, particularly through artificial intelligence and learning analytics, has also significantly changed the educational landscape (Selwyn, 2021; Holmes et al.,

2022; Williamson, 2023). While technology offers opportunities for personalization and scalability, resulting policies often focus on infrastructure rather than meaningful pedagogical integration.

Furthermore, an ethnopedagogical perspective emphasizes the importance of cultural context and local knowledge in enhancing the relevance of learning (Aikenhead, 2021; Tikly, 2020). However, global trends in education policy still tend toward standardization, which potentially neglects local richness (UNESCO, 2021; OECD, 2022).

Table 1. Research Gap in Education Policy Analysis

Approach	Main Focus	Main Weaknesses	Research Gap
Rational-Comprehensive	Systematic planning	Too linear and static	Unresponsive to complexity
Evidence-Based Policy	Quantitative data	Ignoring the socio-cultural context	Minimal interpretive dimension
Interpretive Policy	Meaning & discourse	Less operational	Difficult to implement
Digital Policy	Infrastructure technology	Not pedagogically integrated	Focus on tools, not learning
Neuroscience in Education	Cognitive processes	Not included in the policy	Micro–macro gap
Ethnopedagogy	Local cultural context	Not connected to the policy system	Local–global fragmentation

Table 1 shows that each policy approach has its own contribution, but also leaves significant limitations. The main weakness lies in the inability of these approaches to integrate multiple dimensions simultaneously. This indicates that education policy analysis remains partial and unable to fully address the complexities of the education system. Therefore, this study proposes the Neuro-Techno-Ethno Policy Framework as a conceptual solution to bridge this gap.

The novelty of this research lies in the simultaneous integration of cognitive, technological, and cultural dimensions in one adaptive educational policy framework, which was previously studied separately in the literature.

2. RESEARCH METHODS

This research uses a conceptual qualitative approach with a focus on theory development through critical literature synthesis (Jaakkola, 2020). This approach was chosen because it aims to produce a new conceptual framework that integrates various cross-disciplinary perspectives.

The research procedure was carried out through three main stages: systematic literature mapping, critical comparative analysis, and theoretical synthesis and model construction through an abductive reasoning approach (Timmermans & Tavory, 2019).

The research procedure was carried out through three main stages:

1. **Systematic literature mapping**
   Identifying research developments in education policy, neuroscience, digital transformation, and ethnopedology.
2. **Critical comparative analysis**
   Analyze the tensions between dominant policy paradigms, such as rational, interpretive, and evidence-based approaches.
3. **Theoretical synthesis and model construction through an abductive reasoning approach [18]**

Integrating findings into a conceptual framework through an abductive reasoning approach.

To ensure scientific quality, this research refers to conceptual research criteria including coherence, clarity, originality, and theoretical contribution.

3. RESULTS AND DISCUSSION

4.1 RESULTS

The analysis shows that weaknesses in education policy are not only caused by implementation aspects, but also stem from fundamental conceptual inconsistencies. Further analysis shows that policy inconsistencies do not occur solely in one dimension, but rather result from disharmony across dimensions. This inconsistency creates a gap between policy objectives and the reality of implementation on the ground. There are three main forms of inconsistency:

Table 2. Synthesis of NTEPF Analysis Results

Dimensions	Policy Focus	Main Problem	Solutions in NTEPF
Neuro	Learning process	Not cognitive-based	Neuroscience integration
Techno	Digital infrastructure	Not pedagogical	Technology-learning integration
Ethno	Cultural context	Not contextual	Integration of local values

As shown in Table 2, each dimension has distinct yet interrelated problem characteristics. Therefore, the solutions offered cannot be partial but must be integrated within a coherent framework.

Gambar 1. Neuro–Techno–Ethno Policy Framework (NTEPF)

The figure shows that the relationship between dimensions is dynamic and non-linear. Any change in one dimension will affect the others, so education policy needs to be designed as an adaptive and responsive system to change. The NTEPF framework, as shown in Figure 1, illustrates the integration of cognitive, technological, and cultural dimensions that interact dynamically through an adaptive policy cycle.

This model positions education policy as a non-linear system, but rather as a continuously evolving system through feedback and contextual reflection.

4.2 DISCUSSION

4.2.1. Educational Policy as an Adaptive Complex System

The results of this study indicate that the limitations of education policy lie not solely in technical implementation, but are rooted in the paradigm used in designing the policy itself. Linear policy models are no longer adequate in explaining the dynamics of modern education systems (Cairney, 2021; Weible & Sabatier, 2018). From a complex systems perspective, education policy is viewed as the result of interactions between various actors, structures, and constantly changing contexts. Therefore, policy cannot be positioned as a static instrument, but rather as an adaptive process that requires continuous adjustment. These findings strengthen the argument that the policy approach must shift from a deterministic to an adaptive and reflective one.

4.2.2. Neuro Dimension: Integrating Cognitive Science into Policy

One fundamental weakness in education policy is the lack of an integrated understanding of how humans learn. Policies are often designed based on administrative or structural assumptions, without considering the cognitive and emotional aspects of learners.

In fact, research in neuroscience shows that learning is significantly influenced by emotions and cognition (Immordino-Yang, 2022; Howard-Jones, 2021).

This mismatch between policy and learning mechanisms has the potential to result in ineffective interventions.

In this context, the neuro-dimension within the NTEPF framework serves as an epistemological foundation that ensures policies align with the realities of the learning process. This integration not only enhances learning effectiveness but also strengthens the quality of students' learning experiences.

4.2.3. Techno Dimension: Reorienting Digital Transformation

Digital transformation requires pedagogical integration, not just infrastructure (Selwyn, 2021; Holmes et al., 2022; Williamson, 2023).

The NTEPF framework shifts this paradigm by positioning technology as an integral part of the learning strategy.

The NTEPF framework offers a reorientation by placing technology as part of the pedagogical strategy. This means that the success of digitalization is measured not by the number of devices or platforms used, but by the extent to which technology can improve the quality of learning interactions.

This approach also emphasizes the importance of integrating technology policy with learning objectives. Without such integration, technology risks becoming merely a symbol of modernization without significantly impacting learning outcomes.

4.2.4. Ethno Dimension: Contextualization of Education Policy

The globalization of education brings a tendency toward standardization that often ignores local context. This research shows that policies that are insensitive to cultural context are a significant factor in the effectiveness of

education policies (Aikenhead, 2021; Tikly, 2020). Integrating local values is key to creating an inclusive education system.

The ethno-dimension of the NTEPF emphasizes the importance of integrating cultural values and local knowledge into education policies. This approach not only increases the relevance of learning but also strengthens identity and diversity.

Thus, education policies need to be designed contextually, rather than simply adopting global models directly. This integration is key to creating an inclusive and equitable education system.

4.2.5. Neuro-Techno-Ethno Integration as a New Model

The main contribution of this research lies in integrating three key dimensions into a single, coherent policy framework. Previously, the cognitive, technological, and cultural dimensions tended to be studied separately.

Through the NTEPF, these three dimensions are positioned as an interacting system. This integration allows for more comprehensive policy design, taking into account the various factors that influence learning.

This model also provides a new approach to policy analysis, connecting the micro level (learning processes) with the macro level (policy governance). This represents a significant theoretical contribution to the study of education policy.

4.2.6. Theoretical and Practical Implications

Theoretically, this research expands the study of education policy by presenting a multidimensional approach that has not been widely developed in the literature. Cross-disciplinary integration is a key strength in building a more comprehensive analytical framework.

In practice, the NTEPF framework can be used as a guide in designing adaptive and contextual education policies. This is particularly relevant in addressing the challenges of education in the digital and globalized era.

4.2.7. Towards a Sustainable Learning Ecosystem

The integration of neuro, techno, and ethno dimensions yields the concept of a sustainable learning ecosystem. Adaptive policies align with the global agenda for sustainable education (UNESCO, 2021; OECD, 2022).

Sustainability in education is not only about the system's continuity, but also about its ability to continually evolve in line with the needs of the times. Therefore, education policy must be designed as a dynamic and ongoing process.

4.2.8. Relevance of NTEPF in the Context of Contemporary Education Policy

In the context of contemporary education policy, the NTEPF framework holds significant relevance, particularly in addressing the challenges of digital transformation and cultural diversity. Today's education system is required not only to produce academic outcomes but also to develop students' adaptive skills.

This framework provides a more comprehensive approach than conventional policy models, considering the interaction between cognitive, technological, and cultural aspects simultaneously. This is crucial in ensuring that policies are not only administratively effective but also pedagogically meaningful.

4.2.9. Contribution to the Development of Educational Policy Theory

From a theoretical perspective, this research contributes to broadening the study of education policy by presenting a multidimensional approach that integrates various disciplines. This approach not only enriches the literature but also opens up space for the development of more contextual and adaptive theories.

The integration of neuroscience, technology, and culture within a single policy framework is an attempt to bridge the gap between theory and practice. Thus, this research is not only conceptual but also has significant practical implications.

4.2.10. Policy Implications and Further Research Directions

The policy implications of this research suggest that education policy design needs to consider multiple dimensions simultaneously. A partial approach is no longer adequate to address the complexities of modern education systems.

For further research, empirical studies are needed that can test the implementation of the NTEPF framework in various educational contexts. This is essential to ensure that the proposed model is not only conceptually relevant but also practically implementable.

5. CONCLUSION

This research yields the Neuro–Techno–Ethno Policy Framework as a new conceptual model for educational policy analysis. This framework addresses the gap between learning processes, technology, and cultural context.

The findings suggest that the success of education policy depends heavily on the integration of these three dimensions. Future empirical research is needed to test the implementation of this framework in various educational contexts.

Conceptually, this research emphasizes the need for education policy analysis to shift from a linear approach to a systemic and adaptive one. The NTEPF framework not only offers a theoretical model but also opens up space for developing context-based policies that are more responsive to the dynamics of 21st-century learning.

However, this research is still conceptual in nature so it requires empirical testing in various educational contexts to test the validity and implementability of the proposed model.

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